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Enabling consumer engagement in the future electricity networks

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SUMMARY

Today's electricity system is facing the challenge to respond to growing environmental concerns while assuring sustainable, secure and cost-effective power system operation. Although large scale integration of generation close to load appears as a promising solution to cope with these challenges, much effort is still needed in engaging consumers to take a bigger role in managing their power consumption. In this context, consumer engagement may play a key role in sustaining policy developments that entails an increased share of renewable energy sources in the electricity use together with a more efficient use of electricity energy. Sustainable energy consumption will require a shift towards a two way communication and power flow between consumers and power suppliers in order to optimize the use of renewable energy resources and at the same time to minimize the use of less efficient power generation and network infrastructure investments. In this context, the aim of the present paper is to provide an insight on current trends and development on consumer engagement strategies in smart grid projects in Europe. The paper presents some first results of a periodic survey on European smart grid projects that the Joint Research Centre carries out. One of the aims of the survey is to collect information on ongoing activities at European level on consumer engagement strategies in European smart grids projects. The analysis shows an increase in the interest in consumer engagement in European projects in particular in the residential sector, with ongoing projects being mainly at R&D or demonstration level. Distribution System Operators (DSOs), challenged by the need to integrate increasing shares of renewable and distributed energy sources while ensuring security of system supply, are inherently interested in enhancing flexibility through energy efficiency and dynamic pricing so as to enable consumers responsiveness. Indeed, the survey shows that DSOs have started developing projects aimed at getting to know the consumers' preferences and behaviour and the impact of their choices on system's operators. DSOs, the results show, are acting as one of the key enablers for consumer's integration in the distribution network operation and planning. The paper also presents some results on the main motivational factors behind consumer engagement in smart grids project and finally discusses challenges and strategies in consumer engagement. One concrete example of a successful smart grids deployment program is presented and possibilities of projects scalability are discussed.

KEYWORDS

Smart grids, renewable energy, consumer engagement, distributed energy resources

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1. INTRODUCTION

Europe's electricity system will need to adapt to keep pace with the transformation of the energy world and with changing customer needs. In line with the EU's climate and energy targets, the power sector is striving to achieve a carbon-neutral power supply system by 2050 while assuring sustainable, secure and cost-effective power system operation. This will lead to a significant increase in the amount of electricity produced from renewable sources, such as wind and solar, posing a significant challenge on the future electricity system operation. To this end, much effort is still needed in engaging consumers to take a bigger role in managing their power consumption. In this context, consumer engagement may play a key role in sustaining policy developments that entails an increased share of renewable energy sources in the electricity use together with a more efficient use of electrical energy. Sustainable energy consumption will require a shift towards a two way communication and power flow between consumers and power suppliers in order to optimize the use of renewable energy resources and at the same time to minimize the use of fossil fuel power generation and network infrastructure investments.

In this context, smart electricity grid projects are the first step towards the creation of the future electricity system. It is important, at this early stage, to understand and involve consumers in order for them to successfully assume their new role as active participants in the electric power system. Consumers, their daily routines and the social context in which they operate, should be central to the smart grids community, where the focus is still mainly on technological issues and economic incentives [1].

Many international studies have been recently published where consumers have been approached and interviewed in order to assess their perceptions, understanding and willingness to participate in the development of smart grids technologies [2]; [3]; [4]; [5]. They acknowledge a consumer positive attitude to smart grid technologies, though recognizing the need to address erroneous beliefs and misconceptions that still exist about these new technologies and to strive for trust, transparency and feedback to gain consumer involvement and acceptance.

In this context, the aim of the present paper is to discuss current development on consumer engagement strategies in smart grid projects in Europe. Following the 2011 JRC inventory on smart grid projects [6], a new questionnaire was made available online in March 2012 to collect data on smart grid projects in Europe. The resulting final database is the most updated and comprehensive inventory of smart grid and smart metering projects in Europe: it includes 281 smart grid project and around 100 smart metering pilots and roll-outs. The 2012 on-line questionnaire included a specific section on consumer engagement. Out of the inventoried smart grid projects, 63 have provided information on consumer engagement strategies and activities. The following sections will present some first results of the analysis and a discussion on the main challenges of consumer engagement in smart grids projects. Furthermore, the same issue will be discussed from the DSO perspective, as one of the biggest trigger in adopting consumer engagement strategies. In this context, the level (and respective benefits) of the electricity end-users active engagement in managing their consumption grow up in line with the capabilities of the smart grid potential. Such growth accounts for additional opportunities (and respective benefits), granted to the DSO, to actively control and manage the distribution system while delivering secure, sustainable and cost-efficient electric energy. To this end, a case-study of a successful smart grid deployment, led by the Portuguese DSO is presented and the results are briefly discussed.

2. CONSUMER ENGAGEMENT IN EU SMART GRIDS PROJECTS

2.1 Increasing number of projects with focus on consumer engagement

The number of consumer engagement projects has been increasing since 2005, as shown in Figure 1. In particular, many projects started in 2010 and 2011. Data for 2012 include only projects that were

sent before September 2012 and are not complete. This increasing trend is an acknowledgement of the fundamental role that consumer's observation, engagement and early inclusion will play in the future electricity power system.

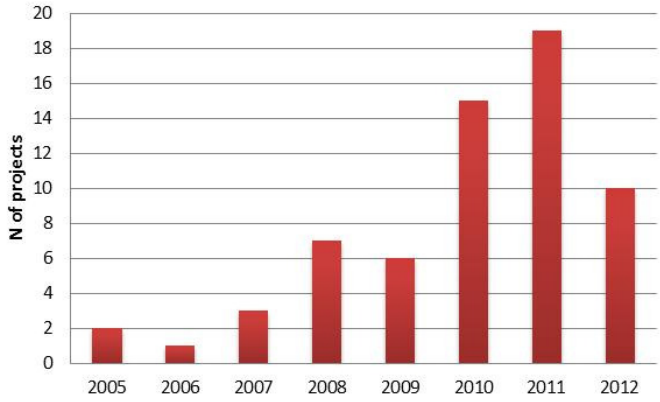

Figure 1: Number of projects with focus on consumer engagement

Most of the collected consumer engagement projects indicate a strong focus on the residential sector, followed by commercial/public services and industrial sector. The predominance of the residential sector can be explained by the need for energy providers to target household consumers. Indeed, residential consumers represent a huge potential for energy savings that energy providers can tap into.

2.2 Leading organizations

Distribution System Operators (DSOs), challenged by the need to integrate increasing shares of renewable and distributed energy sources while ensuring security of system supply, are inherently interested in enhancing flexibility through energy efficiency and dynamic pricing so as to enable consumers responsiveness. Indeed, the survey shows that DSOs have started developing projects aimed at getting to know the consumers' preferences and behaviour and the impact of their choices on system's operators. In this respect, the DSOs, as Figure 2 shows, are acting as one of the key enablers for consumer's integration in the distribution network, leading 43% of the consumer engagement projects in our survey.

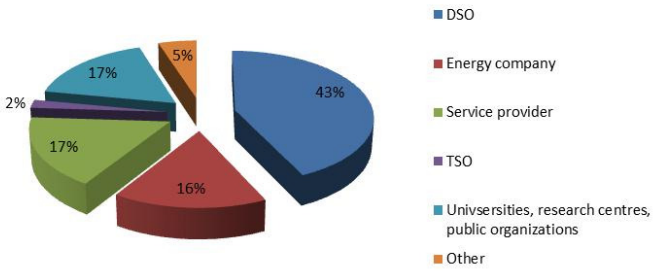

Figure 2: Leading organization in consumer engagement projects

Figure 2 also indicates that energy companies and service providers will also play an important role in enabling the electricity consumers to actively manage their consumption.

2.3 Distribution of projects along the stages of the innovation chain

The collected projects were classified according to their level in the innovation stage. R&D projects cover three activities: basic research, applied research and experimental development. Demonstration projects can be seen as a "preview" phase before commercialization and their aim is to expose technology to realistic user environments to test its suitability for more extensive diffusion. Finally, deployment projects refer to the implementation of a technology, application or system as a default within the project geographical boundaries. As shown in Figure 3, most of consumer engagement projects are in the demonstration phase, 73%, with 27 % of the projects in multinational R&D projects.

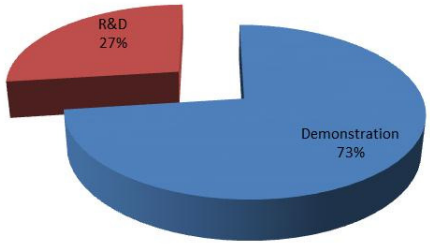

Figure 3: Distribution of projects along the stages of the innovation chain

2.4 Challenges in consumer engagement

Many recent studies acknowledge a consumer positive attitude to smart grid technologies, though recognizing the need to address erroneous beliefs and misconceptions that still exist about these new technologies and to strive for trust, transparency and feedback to gain consumer involvement and acceptance. Indeed the collected projects mainly refer to lack of trust and uncertainties in the use of different motivational factors as critical points in consumer engagement.

Building trust among consumers is a crucial step to overcome consumer resistance to new technical, regulatory and market solutions and to successfully engage them in any energy related project. Many of the collected projects reported a high level of scepticism and wariness. Customers tend to seek relationship with more mutual trust and commitment and to be less sceptical when trusted organizations are involved in the project. Indeed, a number of projects have started building personal contact with consumers through information letters or one-to-one appointments.

Understanding values and motivation that influence consumer choice is of crucial importance to segment consumer on the basis of non traditional factors, like attitudes and motivations associated to energy usage. These factors play a fundamental role to actually trigger behavioural change and are increasingly being used by energy providers as motivational incentives to stimulate consumer engagement and promote smart grid projects.

The analysis of the collected projects shows that the motivational factors commonly used by smart grids projects in Europe are: i) environmental concerns, ii) reduction of/control over electricity bills and iii) better comfort (Figure 4). Most of the projects in our study actually combine more than one motivational factor, usually combining environmental concerns with cost reduction. This result points out that electricity providers are not yet targeting specific customer segments, but are approaching consumers as a whole, trying to appeal them with a combination of different motivational factors. However, many projects point out the difficulty related to the motivational theme “reduction in electricity costs” where they acknowledge the uncertainty about whether consumers will actually be able to experience the benefits. The risk here is that consumer who will not achieve the expected savings, might consider the whole experience disappointing and frustrating [7].

Finally, many projects recognize the limitations linked to the on-going engagement programmes due to the limited size of the consumers involved that may not be representative of larger groups.

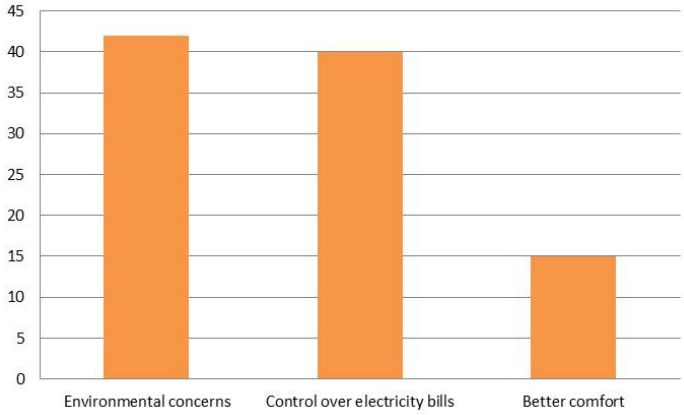

Figure 4: Motivational factors

3. THE ROLE OF DSO IN CONSUMER ENGAGEMENT

3.1 Smart Grid potential in enabling consumer engagement

The Distribution System Operator (DSO), challenged to operate the distribution networks in presence of large amount of variable power generation, appear as one of the leading organisations in recognizing the importance of electricity consumer engagement and enabling consumers' active participation in the distribution network management (Figure 2).

The process of electricity consumer engagement is tightly related with the evolution of the electricity networks. Empowering the consumers to manage their electricity consumption, while enabling them to actively participate in the management of the distribution network operation, exploits to a larger extent the smart grid potential. Figure 5 depicts the level of consumer engagement in line with the evolution of the smart grid potential. The initial level of consumer engagement represents a potentially induced consumer behavior due to the provision of accurate house electricity bill as a result of advanced metering infrastructure (smart metering) installed in the customers' premises. This indirect feedback does not necessarily motivate consumers to reduce energy consumption or trigger energy efficiency. In addition, this initiative is in most cases considered as utility driven oriented to deal with utility operational issues such as outage management and reduction of commercial and technical network losses rather than addressing concerns regarding in-home management and consumer responsiveness [8].
The next level of consumer involvement includes several different types of indirect feedback, such as aggregated (i.e. whole-house) feedback as well as appliance and end-use disaggregated feedback (e.g. estimated appliance-specific, historical comparisons, social comparisons, etc.). These types of feedback are provided by means of web-based presentations and utilize a variety of data sources including electric utility data and other existing types of data (e.g. home energy audits). Able to deliver processed feedback on the consumer's computer, smart phone, iPad, etc., DSOs or third-party service providers empower the end user with mainly two types of feedback: 1) basic energy consumption and cost information, where a customer learns by doing, and 2) leverage existing data to provide personal and social contextual feedback. The second type of feedback provides information about the energy use patterns of other households so as to provide a contextual frame from which any given household can assess their energy consumption performance relative to other people in similar circumstances. Comparisons with neighbors, friends, and communities provide a social context and information about what actions others are taking [9].
Moving to (nearly) real-time, direct feedback provides a wide range of contextual knowledge to users and enables users to learn by doing as well as through the provision of more tailored and socially-relevant feedback.

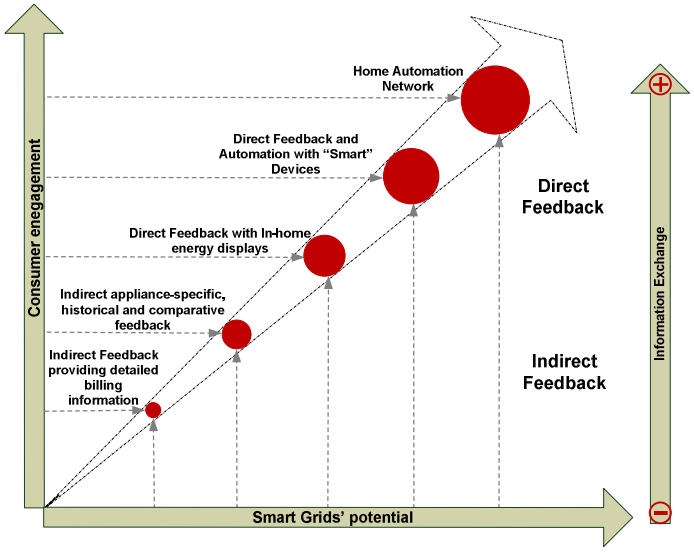

Figure 5: Consumer engagement vs. smart grids' potential (adapted from [8])

For instance, in-home energy management displays provide the potential for "learning by doing" when the user carries the device through the home while switching on and off devices. The user receives immediate, appliance-specific feedback that allows him/her to learn about energy in an incremental fashion.

The next level of end user empowerment consists of energy efficient and "smart" (automated) appliances that can provide direct, real-time feedback, and include appliance-specific information as well as automation. Another critical feature of these smart devices is their capacity to receive pricing signals and utility load control in some cases leading to potential alleviation of distribution network capacity or distribution infrastructure upgrade and thereby reduction of DSO capital expenditures.

Finally, at the core of the ultimate dialogue between the DSO (and/or the retailer) and the electricity end-user is the highest level of real-time feedback, home automation, including energy generation and storage systems. It is a combination of all types of feedback previously described, including energy-efficient and automation enabling-technologies. The complete home energy management system includes a complete network of residential wireless and wired sensor networks, display and feedback devices, and automation that may communicate with the utility. The home automation or home area network supports complete energy management, including information and control for the residential home through a wide selection of interoperable products and services and can effectively integrate smart appliances, distributed renewable generation, and electric vehicles over time.

3.2 Case study: Èvora InovCity

InovGrid, the smart grid project and Évora InovCity, the city where the smart grid project has started are two real examples of the importance and crucial impact that customers have in the development of smart grid projects. InovGrid is used as an open platform, based on public standards, and developing new in-home tools and services supporting customers' involvement by other independent companies, which allow to deeply empowering consumers to make smart decisions about electricity consumption. EDP Distribuição designed an approach for the implementation of the InovGrid project in the InovCity Évora, driven by two main factors: 1) clear value creation for customer must be achieved, and, 2) customers must perceive this value. Worth to note is that the target group was not only technology educated customers, but mainly ordinary electricity customers.

Factors influencing consumer behaviors, as also discussed in section 2 are: 1) making available information about electricity consumption (feedback) and 2) introducing price incentives. To this end, three feedback mechanisms have been presented to the consumers as, shown in Figure 6 [10]:

- Invoice simulation for new tariffs through introduction of: i) Time of use tariffs; ii) Tariffs in relation to the different target consumption levels and iii) Tariffs due to different consumption intervals.

- Indirect feedback (after consumption) – alerts/messages by sms and/or email with information regarding: i) The level of consumption, ii) The power usage against historic data and iii) The time intervals with highest consumption.

- Direct feedback (real-time) through: i) In-home displays with real time connection to the EDP Energy Box (EB), ii) Smart plugs to manage electronic equipment and iii) Web-portals.

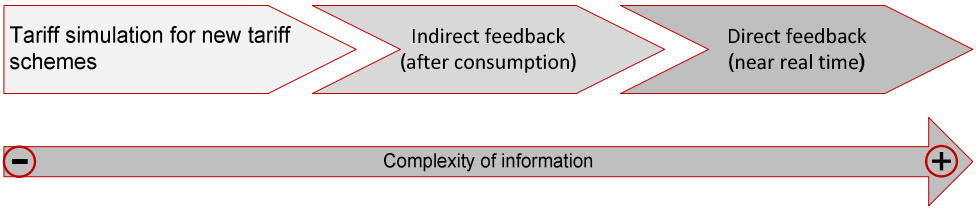

Figure 6: Consumer incentive mechanisms [10]

The project evaluated the impact of an indirect feedback provided to thirty thousand residential low voltage clients, developed together with Qmetrics, an independent company specialized in market studies including support from New University of Lisbon and comprises a complete annual data set. The study is based on comparative analysis between: 1) control group (a neighborhood near Èvora with the same socio-demographic characteristics as the city of Èvora), with customers not being informed about having smart meters installed at their premises) and 2) test group (thirty thousand customers in the city of Èvora being equipped and acknowledged of having smart meters installed).
The initial phase of the study used focus groups and was followed by a first round of door-to-door interviews, involving 511 consumers (about 1,6% of Évora's consumers), with and without smart meters installed to support a social psychology study. A second round of interviews followed the initial phase, involving 515 consumers, divided in two groups – "new users" and "old users". This evaluation study aimed at getting a deeper knowledge on the consumers involved, in particular concerning consumers' attitude towards the EDP smart meter, predictors of consumers' attitude towards the EB, consumers' expectancies and beliefs of EB and identification of EB patterns of use.

The results show that the average daily consumption between the test group and the control group is reduced by 3.9%, at annual basis, with an error margin of 2.1% for a confidence interval of 95%, thus concluding that the reduction is between 1.8% and 6%. This major finding is attributed to both smart metering technology and consumer engagement strategy, and is well above the estimated 2% that support the national business case study, with a clear global economic net present value, and where consumers capture the large majority of benefits. The most relevant predictors towards consumers' positive attitude are found to be the following: *(i)* increase comfort due to remote readings, (ii) invoicing based on real consumption readings, (iii) increased control of energy use, (iv) improved safety associated with remote readings (i.e. consumers don't have to open the door to meter readers), (v) the loss of control over what is charged and (vi) the fear that monthly costs may increase.

The project study indicated that large proportion of consumers has been aware of the Évora InovCity project and recognized it as a project aimed at developing a smart grid. Therefore, the information gathered with these studies is valuable to design consumer engagement strategies and, more generally, to help the company design a smart grid deployment plan that meets consumers' expectancies.

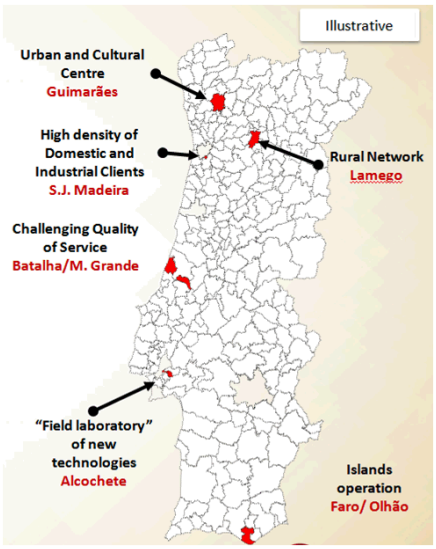

Figure 7: InovGrid scalability potential [11]

Another important feature of the InovGrid project is the ongoing expansion phase to six new locations across Portugal, addressing different challenges to be tackled (Figure 7). This demonstrates a solid potential of the project results to be scaled-up/replicated to other regions, at national level. An added value, in this respect, is the ability of the same to leverage its demonstration and solution replicability potential to a wider European level.

4. MAIN CONCLUSIONS AND FUTURE PERSPECTIVES

Increasing environmental concerns and anticipated scarcity of fossil fuels have paved the way for growing penetration of distributed renewable power generation, where electricity customers should have to take on an active role in managing their electricity consumption. Such scenario poses significant challenges on the operation and management of the distribution networks while providing sustainable, secure and cost-efficient electric energy. To this end, the Distribution System Operators (DSOs), challenged by the need to integrate increasing shares of renewable and distributed energy sources while ensuring security of system supply, are inherently interested in enhancing flexibility through energy efficiency and dynamic pricing so as to enable consumers responsiveness.
In this context, the survey, led by the Joint Research Centre, demonstrated an increasing trend of smart grid projects with electricity consumer engagement, most of them indicated as demonstration project with strong focus on the residential sector. Furthermore, the DSO has been pointed out as one of the key enablers for consumer's integration in the distribution network operation and planning.

Empowering the consumers to manage their electricity consumption, while enabling them to actively participate in the management of the distribution network operation, exploits to a larger extent the smart grid potential. In this respect, the level (and respective benefits) of the electricity consumers engagement in managing their consumption grow up in line with the capabilities of the smart grid potential. Such growth accounts for additional opportunities (and respective benefits), also granted to the DSO, to actively control and manage the distribution system while delivering secure, sustainable and cost-efficient electric energy. For this purpose, a case-study of a successful smart grid deployment, leaded by the Portuguese DSO is presented with results clearly pointing out a creation of a value for the customers involved.

The paper also discussed an insight on the main motivational factors behind consumer engagement in smart grids project. The analysis of the collected projects showed that the motivational factors commonly observed in smart grids projects in Europe are mainly: i) environmental concerns, ii)

reduction of/control over electricity bills and iii) better comfort, though most of the projects combined more than one motivational factor, usually environmental concerns with cost reduction.

To conclude, bringing the customers on board involves adoption of smart metering infrastructure and consumer engagement strategies. The information provided by utility bills needs to be supplemented using all of the evolving layers of incremental consumer engagement enabled with the smart grid potential to provide better visibility of energy information and encourage smart-energy use practices.

The activities of the Joint Research Centre on mapping and assessing consumer engagement strategies are increasing and are tightly interlinked with an online survey carried out on a periodic basis in order to constantly update the picture of smart grid developments in Europe and keep track of lessons learned, challenges and opportunities. This will allow for knowledge sharing and the dissemination of best practices among smart grid stakeholders, contributing to faster inclusion of consumers.

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